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Scientific and Engineering Research Facilities at Universities and Colleges

1994

Executive Summary

National Science
Foundation

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Highlights . . .

- In 1994, the 565 research-performing universities and colleges in the United States had 127 million net assignable square feet (NASF) of science and engineering (S&E) research space. The top 100 institutions had 82 percent of total academic research and development (R&D) expenditures and accounted for 72 percent of this S&E research space. Other doctorate-granting institutions accounted for 24 percent, and the nondoctorate-granting institutions for 4 percent of S&E research space.

- S&E research space has increased since 1988 at an annual average rate of about 2 percent, from 112 million NASF to 127 million NASF in 1994. Other National Science Foundation (NSF) surveys show that research spending grew by just under 9 percent per year and that graduate enrollment increased by nearly 4 percent per year during this same time period.

- More than 40 percent of all research-performing universities and colleges indicated inadequate amounts of S&E research space in engineering, the physical sciences, the biological sciences outside of medical schools, and the medical sciences in medical schools.

- Twenty-six percent of all S&E research space was judged to be "suitable for use in most scientifically sophisticated research," while 17 percent was rated as needing either major repair/renovation or replacement.

- Overall, projects to construct S&E research space totaled $2,812 million in fiscal years 1992–1993. This amount represented a decline of $290 million in constant dollars (dollars adjusted for inflation) from fiscal years 1990–1991, the first decline in construction spending since NSF began collecting data on S&E research facilities.

- Aggregate spending on repair/renovation of S&E research space declined from $861 million in constant dollars in fiscal years 1990–1991 to $837 million in fiscal years 1992–1993. This overall decline resulted from decreased spending by the top 100 institutions; spending for repair/renovation by other doctorate-granting and nondoctorate-granting institutions increased.

- Public universities and colleges accounted for 70 percent of total fiscal years 1992–1993 spending for S&E research facilities construction and repair/renovation. Almost half (46 percent) of their funds came from state or local sources, another 18 percent from tax exempt bonds, and 14 percent each from the Federal government and institutions' own funds.

- In 1994, the estimated cost of unfunded and deferred capital projects that were included in an institutional plan was $5,744 million. These estimates directly reflected the needs of the 40 percent of universities and colleges that had identified these deferred needs in an approved institutional plan.

- For the panel of 29 Historically Black Colleges and Universities (HBCUs) included since the 1988 survey, expenditures for research space construction declined from $83.2 million (constant dollars) in fiscal years 1986–1987 to $8.6 million in fiscal years 1992–1993.

Executive Summary

Universities and colleges are a critical component of the nation's research system. The availability and condition of research facilities at these institutions influence the ability of scientists and engineers to conduct research and train the future science and engineering workforce. Numerous Congressional committees have expressed concerns about the quality of these facilities and the costs of maintaining them. Hearings held in both House and Senate committees on science and technology in the mid-1980s led to the conclusion that the condition of these facilities posed a "serious and ongoing problem . . . ." However, insufficient information existed to assess the extent of the problem.

Recognizing the need for information on the amount and quality of scientific and engineering (S&E) research space, Congress mandated that the National Science Foundation (NSF) gather this information and report it to Congress:

> *The National Science Foundation is authorized to design, establish, and maintain a data collection and analysis capability in the Foundation for the purpose of identifying and assessing the research facilities needs of universities and colleges. The needs of universities by major field of science and engineering, for construction and modernization of research laboratories, including fixed equipment and major research equipment, shall be documented. University expenditures for the construction and modernization of research facilities, the sources of funds, and other appropriate data shall be collected and analyzed. The Foundation, in conjunction with other appropriate Federal agencies, shall report the results to the Congress. The first report shall be submitted to the Congress by September 1, 1986* (42 U.S.C. 1886).

Since 1986, NSF has collected data on a biennial basis to address these concerns of Congress. The first study, a "quick response" survey, provided limited data regarding S&E facilities issues. In 1988, 1990, 1992, and 1994, full-scale surveys have provided considerable information about the nations' academic research facilities.

This report describes the findings from the 1994 survey and places them in historical context by comparing results with those from earlier surveys. Following a brief discussion of the study methods, the remainder of this executive summary addresses several key questions regarding S&E research space in research-performing universities and colleges:

- How much space is available for S&E research, and how has this changed over time?
- How much more space is needed?
- How good is the existing space, and what improvements are needed?
- What is being done to address these needs?
- Where does the money come from?
- What more remains to be done?

The final section of the summary profiles two distinct groups of institutions that play important roles in the training of future scientists and engineers: Historically Black Colleges and Universities (HBCUs) and a select group of academic institutions that are oriented primarily to undergraduate education. These predominantly undergraduate institutions consist of comprehensive universities and liberal arts colleges.

What Methods Did This Study Use?

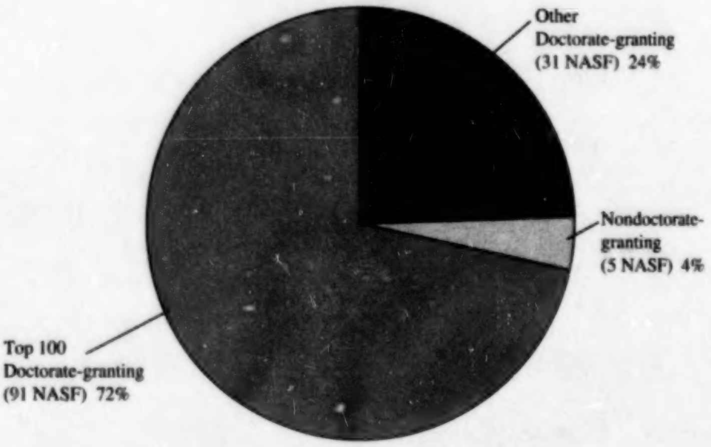
The 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges collected data from a universe of 565 institutions, which included all those with research and development (R&D) expenditures of $50,000 or more and HBCUs with any R&D expenditures.

The 1994 survey was mailed to all sampled institutions in the fall of 1993. Extensive telephone follow-up was used to elicit a 93 percent response rate and to resolve questions regarding incomplete or inconsistent responses. Sampled institutions that had participated in the 1992 survey were also sent a computer-generated "facsimile" of their previous responses. (See Appendix A, *Technical Notes*, for a detailed description of the sampling procedures and data collection methods.)

How Much Space Is Available for S&E Research, and How Has This Changed Over Time?

In 1994, universities and colleges devoted about 282 million net assignable square feet (NASF) of space to S&E fields. Of this space, about 127 million NASF was devoted to research.[1] The top 100 institutions in R&D expenditures housed the most S&E research space, 91 million NASF, comprising about 72 percent of all S&E research space (Figure 1).[2] The top 100 institutions also had 82 percent of total academic R&D expenditures.

Figure 1. Top 100 doctorate-granting institutions have 72 percent of the total 127 million net assignable square feet (NASF) of science and engineering research space: 1994
[NASF in millions]



SOURCE: National Science Foundation/SRS, 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges

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[1] Throughout this report, research is defined as "all research and development activities of an institution that are budgeted and accounted for." Research can be funded by the Federal government, state governments, foundations, corporations, universities, or other sources. "Research space" refers to the net assignable square footage of space within research facilities (buildings) in which research activities take place. Multipurpose space, such as an office, is prorated to reflect the proportion of use devoted to research activity.

[2] The "top 100" designation is based on institutions' fiscal year 1991 research expenditures, as reported in *Academic Science and Engineering: R&D Expenditures, Fiscal Year 1991*, National Science Foundation, 1993.

Since 1988, the amount of S&E research space has increased steadily, growing at an average rate of about 2 percent per year. From 1988 to 1994, the available S&E research space grew from 112 to 127 million NASF.[3] Most of this increase occurred in the top 100 institutions; engineering experienced the largest growth of any single S&E field.

How Much More S&E Research Space Is Needed?

To answer this question, institutions assessed, for each S&E field, how adequate the amount of existing space was for current research programs. Of those institutions with some research space in each field, at least 40 percent reported inadequate amounts of space in four S&E fields:

- Engineering
- Physical sciences
- Biological sciences outside of medical schools; and
- Medical sciences in medical schools.

The institutions that had the most S&E research space also expressed the greatest need for more space. Over half of the top 100 institutions reported inadequate amounts of research space in all four of the above S&E fields. Fewer than 40 percent of the nondoctorate-granting institutions reported inadequate amounts of space in any field.

How Good Is Existing S&E Research Space, and What Improvements Are Needed?

Of all S&E research space, over a quarter (33 million NASF) was considered suitable for the most sophisticated research, a result driven by the high quality of space at doctorate-granting institutions. Both the top 100 institutions and other doctorate-granting institutions designated about 27 percent of their overall space as "suitable for use in the most highly developed and scientifically sophisticated research . . . ." The nondoctorate-granting institutions classified 16 percent of their space into this category.

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[3] The reported figures are conservative estimates of the total amount of space used for S&E research in academic settings. Space used for organized research but also for other purposes is prorated to reflect the proportion of research usage.

The second category of space, space that is "suitable for most uses," included another 33 percent of the total S&E research space. This percentage was fairly consistent across doctorate-granting institutions. Nondoctorate-granting institutions rated 42 percent of their space as belonging to this category.

Twenty-three percent of existing S&E research space was considered to need limited repair/renovation. This percentage was generally consistent across institution types. Thirteen percent of S&E research space was rated as needing major repair/renovation, and another 4 to 5 percent required replacement.

Repair/renovation needs were concentrated in a few S&E fields. The single field requiring the largest proportion of major repair/renovation or replacement was agricultural sciences, in which 22 percent of the existing research space was rated in this category. However, few institutions (20 percent) had agricultural sciences research space. In environmental sciences, about 19 percent of the existing research space needed major repair/renovation or replacement.

Other fields in which 15 percent or more of the total S&E research space needed major repair/renovation or replacement included the biological sciences outside of medical schools (19 percent); the physical sciences (18 percent); the medical sciences, both within and outside medical schools (17 percent for both); engineering (15 percent); and the biological sciences in medical schools (15 percent).

What Is Being Done to Address S&E Research Facility Needs?

In fiscal years 1992–1993, universities and colleges began over $2,812 million of construction for S&E research space. Most of this construction activity, approximately $2,000 million or 72 percent, occurred at the top 100 institutions. Other doctorate-granting institutions spent approximately $691 million on the construction of new S&E research space, and nondoctorate-granting institutions spent $92 million.

For the first time since NSF began collecting data on S&E research facilities, in fiscal years 1992–1993, the inflation-adjusted amount (the constant dollar amount) spent on construction of S&E research space declined.[4] (See Figure 2 on the following page.)

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[4] This report used the Bureau of the Census' Composite Fixed-Weighted Price Index for Construction to adjust construction dollar amounts for inflation.

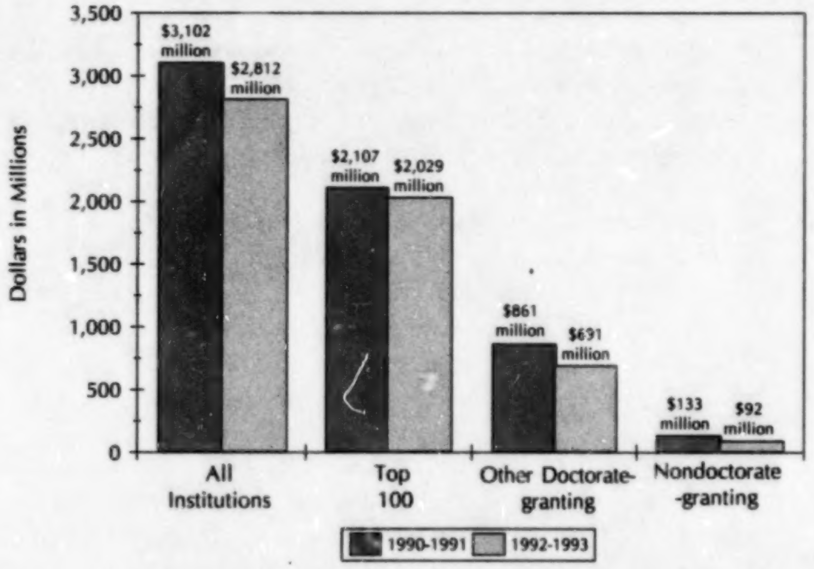


Figure 2. Dollars for construction projects for science and engineering research space declined since fiscal years 1990-1991
[Constant 1993 dollars in millions]

SOURCE: National Science Foundation/SRS, 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges

Repair/renovation spending for existing S&E research space also declined to $837 million in fiscal years 1992–1993 from $861 million in fiscal years 1990–1991, continuing the decline that began in fiscal years 1988–1989. The decline in repair/renovation was driven by a decline at the top 100 institutions.

Some level of capital projects (either construction or repair/renovation) took place at almost half (46 percent) of all institutions during fiscal years 1992–1993. However, almost all of the top 100 institutions (90 percent) began capital projects, while 25 percent of the nondoctorate-granting institutions did so. Forty-eight percent of the other doctorate-granting institutions began capital projects in fiscal years 1992–1993.

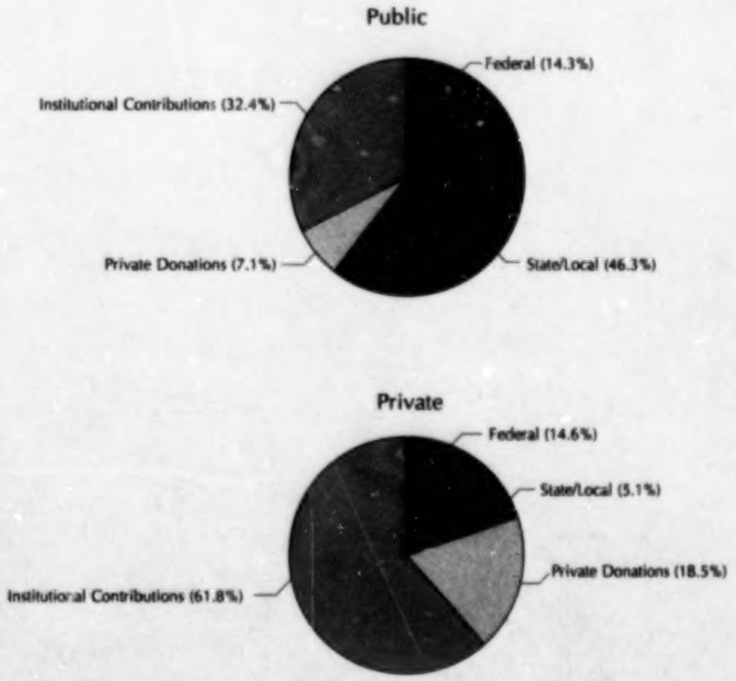
As noted above, agricultural sciences was the S&E field with the largest proportion of space that needed major repair/renovation or replacement. With the exception of S&E fields in medical schools (biological and medical sciences), agricultural sciences was also the field in which the highest percentage of institutions was undertaking construction projects. In fiscal years 1992–1993, 27 percent of all institutions with research space in the agricultural sciences had construction projects underway in that field.

Institutions were more likely to have begun repair/renovation projects than construction projects in most S&E fields. The two exceptions were agricultural sciences and mathematics. In agricultural sciences, 27 percent of all institutions began construction, and 18 percent began repair/renovation projects. In mathematics, 2 percent of all institutions began both construction and repair/renovation projects.

Who Funds Capital Projects?

In fiscal years 1992–1993, public and private institutions drew upon substantially different sources to fund the construction and repair/renovation of S&E research space. Public institutions relied primarily on state and local funding, which accounted for 46 percent of their total funding for capital projects. Private institutions relied primarily on institutional contributions (institutional funds, tax-exempt bonds, and other debt); these funds accounted for 62 percent of the total funding for their capital projects (Figure 3).

Figure 3. Public and private institutions have different funding sources of capital projects for construction and repair/renovation of science and engineering research space: 1994



SOURCE: National Science Foundation/SRS, 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges

At public institutions, capital funding declined about 4.5 percent between fiscal years 1986–1987 and fiscal years 1992–1993. Private institutions experienced a large drop in capital funding from state and local governments between fiscal years 1990–1991 and the following two fiscal years of 1992–1993. However, the high level of state and local capital funding that private institutions received in fiscal years 1990–1991 was somewhat atypical; it was considerably higher than at any time since fiscal years 1986–1987.

What More Remains to Be Done?

Congress is concerned with determining what universities and colleges need with regard to S&E research space. Determining need is a complex matter, because what is needed must be placed within a framework that is realistic from a budgetary perspective.

In an effort to measure real (as opposed to speculative) needs, the 1994 survey adopted a conservative approach to this issue. (See Appendix A, *Technical Notes*, for a discussion of differences from previous surveys.) It combined institutions' assessments of S&E research space needs with deferred plans to repair/renovate or to construct S&E research space. Institutions reported whether an approved institutional plan existed that included "any deferred space that requires new construction or repair/renovation." Four criteria were used to define deferred space:

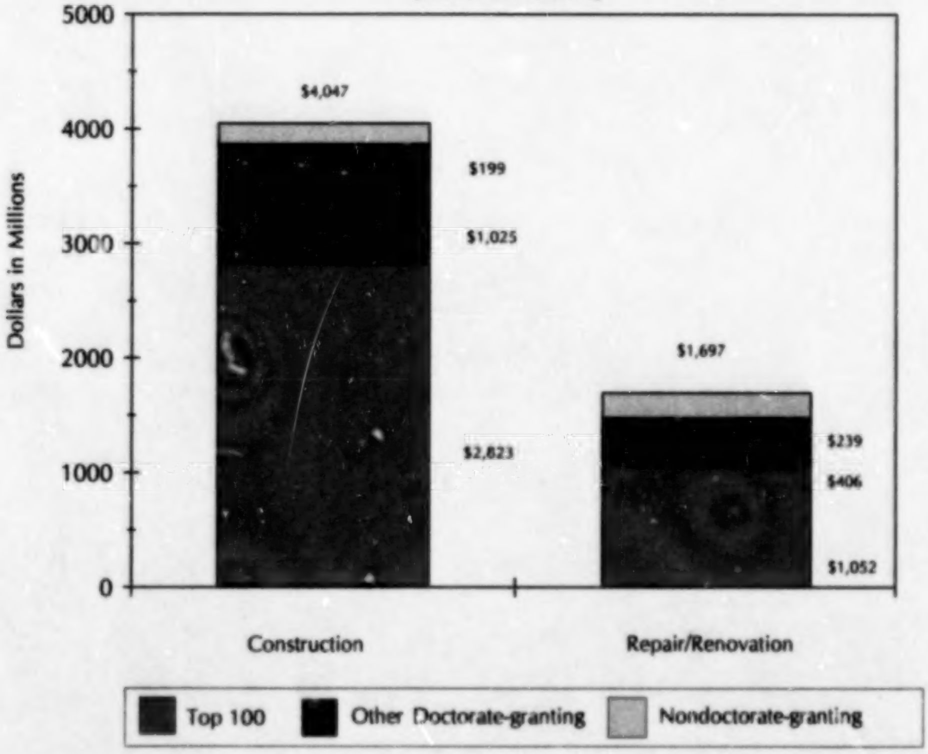
- The space must be necessary to meet the critical needs of current faculty or programs;
- Construction must not be scheduled to begin during fiscal years 1994–1995;
- Construction must not currently have funding; and
- The space must not be for developing new programs or expanding the number of faculty.

Using these standards, respondents were asked to estimate for each S&E field the construction and repair/renovation costs of such deferred projects.

The strength of this approach is the fact that institutions must make decisions about the distribution of scarce resources to develop and approve these plans. In short, these plans are not wish lists. Therefore, when approved institutional plans include construction or repair/renovation that is deferred (i.e., not planned for fiscal years 1994–1995), it is reasonable to see these deferred projects as needed projects yet to be addressed. Forty percent of responding institutions could report deferred space meeting these criteria; sixty percent did not; the information reported here is based on reports from the forty percent. Although a less formal definition might well lead to a different estimate than the one reported here, the needs expressed based on these criteria provide a framework for meaningful interpretation of results and the development of trends over future years. These estimates reflect a thoughtful process of deliberation and compromise at the responding institutions.

Deferred capital projects at the 40 percent of institutions with institutional plans amounted to $5,744 million. Of this, $4,047 million reflected needs for construction, and $1,697 million reflected needs for repair/renovation (Figure 4).

Figure 4. Unfunded science and engineering capital needs total $5,744 million [Dollars in millions]



SOURCE: National Science Foundation/SRS, 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges

The fields in which capital projects were most often deferred included engineering, with 18 percent of responding institutions reporting deferred capital projects; the physical sciences, with 16 percent reporting deferred capital projects; the medical sciences in medical schools, with 16 percent; and the biological sciences outside of medical schools, with 14 percent.

What Is the State of S&E Research Facilities at Historically Black Colleges and Universities?

Historically Black Colleges and Universities (HBCUs) have played an important role in the education of black students at all higher education levels for over 100 years. These universities and colleges consist of both public and private institutions as well as two-year, four-year, and professional schools. In 1991, approximately 269,000 students attended the 105 institutions of higher education considered HBCUs by the U.S. Department of Education. Although the HBCUs have considerably less S&E research space than other research-performing institutions, the HBCUs are an important source of science and engineering degrees for the black students who are currently enrolled in college.[5]

Research-performing HBCUs contained 7.9 million NASF of S&E space, of which 2.2 million were devoted to research. Among a panel of 29 institutions that has been sampled consistently since 1988, the amount of S&E research space dropped slightly, from 1.78 million NASF in 1988 to 1.76 million in 1994.

HBCUs reported that their S&E research space was in fairly good shape. Over 30 percent of space was reported to be suitable for the most sophisticated research, and 9 percent was in need of major repair/renovation.

Construction starts at HBCUs continued a precipitous decline. In fiscal years 1986–1987, the panel of 29 HBCUs spent $83.2 million in constant dollars on construction of S&E research space. By fiscal years 1992–1993, this figure had dropped to $8.6 million, about a tenth of its earlier level. (See Figure 5 on the following page.)

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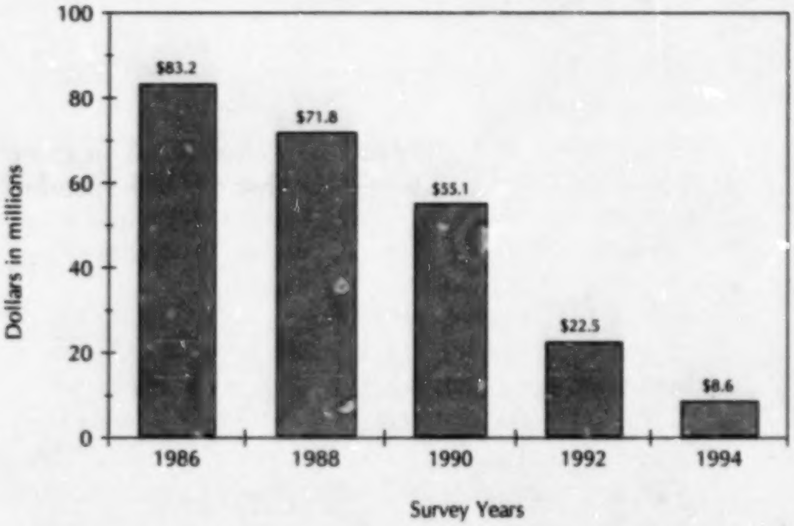
[5] A recent study of science and engineering doctorates revealed that almost 30 percent of black science and engineering doctorate degree recipients between 1985 and 1990 received their bachelors degrees from HBCUs.

Figure 5. Funding for construction at Historically Black Colleges and Universities has declined
[Constant 1993 dollars in millions]



SOURCE: National Science Foundation/SRS, 1994 Survey of Scientific and Engineering Research Facilities at Universities and Colleges

HBCUs continued to receive most of their funding for S&E research space construction and repair/renovation from the Federal government.

What Is the State of S&E Research Facilities at Predominantly Undergraduate Institutions?

In the National Science Foundation Authorization Act of 1994, the Committee on Science, Space, and Technology expressed concern "that NSF's biennial survey of academic research facilities needs ... has not focused adequately on the needs of undergraduate institutions." The 1994 facilities survey, in the field at the time, was not designed to collect data regarding the specific needs of undergraduate institutions. Furthermore, the sampling frame for this study did not represent all the types of undergraduate institutions of concern to Congress. Nevertheless, the 1994 survey and sample can provide insights into several issues regarding the S&E research facilities of a select group of undergraduate institutions.

Predominantly undergraduate institutions that engaged in separately budgeted S&E research had a total of approximately 25 million NASF of space in S&E disciplines. Analysis divided these institutions into two groups: comprehensive universities (institutions that granted a master's degree as well as a bachelor's degree) and liberal arts colleges. Over 80 percent of the S&E space at predominantly undergraduate institutions was in the comprehensive universities.

Of all S&E space at predominantly undergraduate institutions, only 17 percent was devoted to S&E research, as might be expected because of their educational mission. Almost half of this space was characterized as "effective for most purposes," though not generally suitable for the most advanced research. Approximately 3 percent of the S&E research space was classified as in need of replacement, about the same as all other institutions.

To address S&E research space needs, these institutions invested a total of about $92.3 million in capital projects in fiscal years 1992–1993. Of this total, $65.2 million was spent on construction and $27.1 million was spent on repair/renovation. Of the predominantly undergraduate institutions which had an approved institutional plan that included deferred or unfunded capital projects for S&E research space, deferred capital projects totaled over $356.6 million.

END

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